N92-10813

REMOTE SENSING OF THE MARTIAN SURFACE. Bruce M. Jakosky, Bradley G. Henderson, Cora E. Randall, M. Joan Alexander, and Thomas M. McCollom*, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309-0392. * Now at Washington University in St. Louis.

The martian surface has been extensively imaged from orbiting spacecraft, revealing processes which affect the surface at spatial scales of tens of meters and larger. At smaller scales, available orbiter imaging or observations from landers are not available over a large fraction of the surface; remote-sensing observations are used to determine global surface properties and thereby infer the nature of ongoing surface processes. The various remote-sensing techniques, including radar reflection and scattering and thermal emission observations at multiple times of day, wavelengths, or viewing geometries, are sensitive to the properties of the surface at spatial scales ranging from tens of microns up to meters. The processes which are responsible for producing properties at this scale, or for producing spatial variations in these properties, include eolian erosion and deposition, physical and chemical weathering of surface materials, and solution or precipitation of materials due to the possible presence of liquid water.

As part of our ongoing research program, we have been investigating the physical properties of the martian surface as inferred from a combination of orbiting and Earth-based remote-sensing observations and in-situ observations. This approach, to synthesize a variety of different observations, each of which is sensitive to slightly different aspects of the near-surface layer, provides the most-detailed and self-consistent view of the global and regional nature of the surface.

Our results during the past year focus on the areas of (i) modelling the diurnal variation of the surface temperature of Mars incorporating the effects of atmospheric radiation, with implications for the interpretation of surface thermal inertia; (ii) modelling the thermal emission from particulate surfaces, with application to observations of the surfaces of the Earth, Moon, and Mars; (iii) modelling the reflectance spectrum of Mars in an effort to understand the role of particle size in the difference between the bright and dark regions; and (iv) determining the slope properties of different terrestrial surfaces and comparing them with planetary slopes derived from radar observations.

The correct interpretation of surface temperature measurements in terms of the thermal inertia (and, hence, particle size) of the surface depends on understanding the energy balance at the surface. We completed our initial analysis of the atmospheric radiative effects on the diurnal temperature behavior of the martian surface, with implications for the derivation of thermal inertia of the surface and the particle size of surface materials. In addition, we did preliminary analysis of the Phobos eclipse observations; although we did not construct the required detailed eclipse thermal model, we did some simple scaling analysis that should correctly predict the magnitude of the atmospheric correction which should be applied. The interpretation of these results in terms of the derived thermal inertia of the surface affects the inferences of particle size of the surface materials; our results suggest that the thermal inertias are lower than previously thought, and that the particle sizes are smaller. A paper on these results has been submitted to Icarus, and is now in press and should appear before summer (Haberle and Jakosky, 1991).

Previous work in thermal infrared emission was carried out as part of the Geological Remote Sensing Field Experiment (GRSFE). We measured the emission from various surfaces, of different roughnesses, at a variety of emission angles. A Monte Carlo model of infrared emissivity from powdered materials has been constructed and applied to some of the results from the GRSFE experiment. The model traces individual photons through the emission process, and incorporates both emission from individual grains and scattering of energy between grains. The scattering process correctly includes the polarization of the radiation throughout the scattering and emission process. The model has been applied to the observed variation of emission from a sand surface as a function of emission angle, obtained as part of our GRSFE experiment, and reproduces the observations with no free parameters. Additionally, the model has been applied to observation of oblique emission from the Moon (as in the telescopic observations of Prof. Paul Lucey), the role of multiple scattering in affecting the observed infrared emission spectrum, and the possible polarization of thermal emission at different viewing angles. Preliminary results have been presented at the 1990 Fall A.G.U. Meeting in San Francisco (Henderson et al., 1990) and will be discussed in the context of other GRSFE analyses at a special session at the 1991 Spring A.G.U. Meeting in Baltimore (Jakosky et al., 1991). We hope to have a manuscript on these results prepared by the beginning of summer.

We have almost completed a modelling study of the role of particle size in determining the visible and near-infrared (VNIR) reflectance of the martian surface. The results were based on a comparison between martian bright- and dark-region spectra; the lack of any spectral features in the ratio of the two, except for a smooth variation from shorter to longer wavelengths, suggested that the bright and dark regions might differ primarily in their particle size and the resulting difference in scattering efficiency. We used Hapke's model of the reflectance of a surface, as a function of particle size and optical constants, to examine this possibility in two different ways. First, we used constant optical properties in order to understand the role of particle size in determining the VNIR continuum, rather than using the standard technique of drawing some sort of a straight-line continuum. Second, we used the optical constants of putative martian surface materials to directly determine the effects of varying the particle size of the surface. The results indicated that proper interpretation of the Mars spectral reflectance, and in particular interpretation of the differences in the spectra of bright and dark regions, required the incorporation of particle size variations in the analysis. Preliminary results were presented at the 1990 Fall A.G.U. Meeting in San Francisco (Alexander and Jakosky, 1990), and a manuscript is currently in preparation.

Finally, we examined the distribution of surface slopes of a number of terrestrial surfaces by field measurement, and compared the results to planetary radar data. Slope distributions of the measured surfaces differed considerably from the distributions assumed by accepted models of radar scattering. Rms slope values for the terrestrial surfaces ranged from 0 to 16.5 degrees, compared to a range of rms slope values of <1 to 10 degrees for planetary surfaces as inferred from radar observations. While the great majority of planetary surfaces observed by radar have rms slope estimates in the lower end of this range, nearly all of the terrestrial surfaces we measured have rms slope values greater than 5 degrees. We also used the Hagfors model of radar scattering to predict the return that would be expected from surfaces where two discrete surface types were present within the radar field of view, and found that the shapes of the predicted spectra differed from those predicted for homogeneous surfaces; additionally, the resulting best-fit rms slope was a non-linear combination of those of the pure surfaces, emphasizing the smoother surface. Together, these results suggest that current methods of determining surface roughness from radar significantly underestimate the roughness of planetary surfaces, and that the derived rms slope can only be used as a qualitative guide to actual surface properties. A manuscript by McCollom and Jakosky which details these results has been submitted for publication.